surface of the Amuri Limestone as exposed at Weka Pass, but to the exposures at the Upper Waipara, where fossils were recently found in the Weka Pass Stone by Dr. Thomson and concerning which I was writing at the time.[1]

The evidence of an unconformity between the Weka Pass Stone and Amuri Limestone at Weka Pass is very meagre, but at the Upper Waipara the corroded, shattered, and brecciated upper surface of the Amuri Limestone certainly favours Hutton's view of unconformity; and comparing the evidence with that I have seen at the junction of the Eocene and Cretaceous in the section across the Isle of Wight, in the Hampshire Basin, in different parts of the Gallic Basin, in North-West Germany, and in Northern Africa, I have no doubt that European geologists would support Hutton's contention. But the question after all is not dependent on physical conformity or unconformity, but on the broader platform of palæontology. So long as a Cretaceous fauna is held to typify a Cretaceous age and a Tertiary fauna a Tertiary age, so long must Hutton's Waipara and Oamaru Systems stand as typical of New Zealand's Cretaceous and Lower Tertiary formations respectively.

V.—On the Important Part played by Calcareous Algæ at certain Geological Horizons, with Special Reference to the Palæozoic Rocks.

By Professor E. J. Garwood, M.A., V.P.G.S.[2]

MORE than twenty years ago, whilst engaged in the study of the Lower Carboniferous rocks of Westmorland, I noticed the occurrence of certain small concretionary nodules of very compact texture in the dolomites near the base of the succession in the neighbourhood of Shap.

Shortly afterwards, when examining the Bernician rocks of Northumberland, I again met with similar compact nodular structures. It was obvious, however, even at that time, that the Northumberland specimens occurred here at a much higher horizon than those which I had observed in Westmorland.

More recently, whilst studying the lithological characters of the Lower Carboniferous rocks of the North of England and the Border country, I have been still further impressed by the abundance of these nodular structures at several horizons, and the large tracts of country over which they extend. An examination of these nodules in thin sections showed their obvious organic character, and I was at first inclined to refer them to the Stromatoporoids. Dr. G. J. Hinde, who was kind enough to examine my specimens from the Shap district, reported, however, that they were probably not Stromatoporoids, but Calcareous Algæ,[3] and referred me to the descriptions of *Solenopora* published by the late Professor Nicholson and Dr. Brown.

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[1] "The Supposed Cretaceo-Tertiary Succession of New Zealand," Geol. Mag., November, 1912, pp. 496–7.

[2] Being the substance of his address to the Geological Section of the British Association for the Advancement of Science, Birmingham, 1913 (President of Section C).

[3] See Geol. Mag., 1913, pp. 289–92, Pl. X: Dr. G. J. Hinde on *Solenopora*.

Since then I have examined a large number of nodules collected from different horizons in the Lower Carboniferous rocks of Britain and Belgium, and the examination has convinced me that the remains of Calcareous Algæ play a very much more important part in the formation of these rocks than has hitherto been generally realized.

The majority of geologists in this country have been slow to recognize the importance of these interesting organisms, and, with the notable exception of Sir Archibald Geikie's textbook, we find but scant allusion in English geological works of reference to the important part played by Calcareous Algæ in the formation of limestone deposits.[1]

From the more strictly botanical standpoint, however, we are indebted to Professor Seward for an admirable account of the forms recognized as belonging to this group up to the date of the publication of his textbook on Fossil Plants in 1898; while in an article in *Science Progress* in 1894 he has also dealt with their importance from a geological point of view.

Since these publications, not only have several new and important genera been discovered in this country and abroad, but the forms previously known have also been found to have a very much wider geological and geographical range than was formerly suspected. For these reasons I venture to hope that a summary of our knowledge of the part they play as rock-builders, more especially in British deposits, will serve to stimulate an interest among geological workers in this country in these somewhat neglected organisms.

Previous to 1894, in which year Dr. Brown first referred *Solenopora* to the Nullipores, with the exception of the Jurassic and Tertiary Characeæ, we meet with little, if any, reference to the occurrence of fossil Calcareous Algæ in British deposits.

Indeed, in this country the subject has attracted but few workers, and they can almost be counted on the fingers of one hand. When we have mentioned the late Professor H. A. Nicholson and Mr. Etheridge, jun., Mr. E. Wethered, Dr. Brown, Dr. Hinde, and Professor Seward, we have practically exhausted the list of those who have contributed to our knowledge of the subject. To these we may add the name of Mrs. Robert Gray, whose magnificent collection of fossils from the Ordovician rocks of the Girvan district has always been freely placed at the disposal of geological workers, and has furnished numerous examples of these organisms to Professor Nicholson and the officers of the Geological Survey.

It was Nicholson and Wethered who first recognized the important part played in the formation of limestones by certain organisms, which, though referred at the time to the animal kingdom, are now generally considered to represent the remains of Calcareous Algæ.

The presence of these organisms in a fossil state, especially in the older geological formations, has only been recognized in comparatively recent years; though it was suggested as long ago as 1844 by Forchhammer[2] that fucoids, by abstracting lime from sea water, probably contributed to the formation of Palæozoic deposits. When we remember that it was not until the researches of Philippi were published in 1837 that certain calcareous deposits were discovered to be directly due to the growth of living forms of lime-secreting algæ, it is not surprising that only in comparatively recent years has the importance of the fossil forms as rock-builders in past geological formations been recognized.

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[1] Geikie, *Textbook of Geology*, 4th ed., vol. i, pp. 605, 611, 1903.

[2] British Association, 1844, p. 155.

The original genera established by Philippi—namely, *Lithothamnion* and *Lithophyllum*—are known now to have a wide distribution in the present seas, and it is therefore natural that it was members of these groups which were the first to be recognized in a fossil state in Tertiary and, subsequently, in Upper Cretaceous rocks.

Thus in 1858 Professor Unger, of Vienna, showed the important part played by *Lithothamnion* in the constitution of the Leithakalk of the Vienna Basin, while seven years later Rosanoff contributed further to our knowledge of Tertiary forms. In 1871 Gümbel published his monograph on the "so-called Nullipores found in limestone rocks", with special reference to the *Lithothamnion* deposits of the Danian or Maestricht beds. Since then *Lithothamnion* has also been reported from Jurassic rocks, and even from beds of Triassic age, though in the latter case, at all events, the reference to this genus appears to require confirmation. In this country the recognition of fossil Calcareous Algæ dates from a considerably later period. It will be best first to review the chief genera which appear to be referable to the Calcareous Algæ, and afterwards to show the part they play as rock-builders in the different geological formations.

Two important genera are usually recognized at the present day as occurring in the British Palæozoic and Mesozoic rocks—namely, *Solenopora* and *Girvanella*—and to these I propose to add Wethered's genus, *Mitcheldeania*, together with certain new forms from the Carboniferous rocks of the North of England, which appear also to be referable to this group.

Solenopora.

This genus was first created by Dybowski in 1877 for the reception of an obscure organism, from the Ordovician rocks of Esthonia, which he described under the name *Solenopora spongioides* and regarded as referable to the Monticuliporoids.

Nicholson and Etheridge in 1885 (Geol. Mag., p. 529) showed that the form described by Billings in 1861 as *Stromatopora compacta*, from the Black River limestones of North America, was in reality Dybowski's genus *Solenopora*, and in all probability was specifically identical with the form from Esthonia. Moreover, they considered that the organism they themselves had described under the name of *Tetradium Peachii* in 1877, from the Ordovician rocks of Girvan, was also referable to Billing's species, though perhaps a varietal form. Thus *Solenopora compacta* was shown to have a very wide distribution in Ordovician times.

Nicholson in 1888 defined the genus as including "Calcareous organisms which present themselves in masses of varying form and irregular shape, composed wholly of radiating capillary tubes arranged in concentric strata. The tubes are in direct contact, and no cœnenchyma or interstitial tissue is present. The tubes are thin-walled, irregular in form, often with undulated or wrinkled walls, without mural pores, and furnished with more or fewer transverse partitions or tabulæ".[1]

At that time Nicholson still considered *Solenopora* as representing a curious extinct hydrozoon, though already, in 1885, Nicholson and Etheridge had discussed its possible relationship to the Calcareous Algæ. They did not, however, consider that there was sufficient evidence for concluding that the true structure of *Solenopora* was cellular, but added: "If evidence can be obtained proving decisively the existence of a cellular structure in *Solenopora*, then the reference of the genus to Calcareous Algæ would follow as a matter of course."[2]

In 1894 Dr. A. Brown[3] investigated more fully the material which had been placed in his hands by Professor Nicholson, and gave an account of all the forms referable to *Solenopora* known at that date.

To those already recorded he added descriptions of four new species from the Ordovician rocks—namely, *S. lithothamnioides*, *S. fusiformis*, *S. nigra*, and *S. dendriformis*, the two latter being from the Ordovician rocks of Esthonia.

In the same paper also he published for the first time a description of a new species of *Solenopora* from the Jurassic rocks of Britain, to which Nicholson, in manuscript, had already assigned the name of *S. jurassica*, though, as will be pointed out later, it is probable that two distinct forms were included by Brown under this name.

This record of *Solenopora* from the Lower Oolites of Britain extended the known range of this genus, for the first time, well into the Jurassic period. In this paper Brown first brought forward good evidence for removing *Solenopora* from the animal kingdom, and placing it among the Coralline Algæ, and Professor Seward, in vol. i of his work on *Fossil Plants*, considers that there are good reasons for accepting this conclusion.

At the time of the publication of Dr. Brown's paper, and for some years afterwards, the only formations in which *Solenopora* was known to occur were the Upper Ordovician and the Lower Oolites. The diversity of forms, however, met with in the Ordovician rocks, and their widespread distribution, pointed to the probability of the existence of an ancestral form in the older rocks, while it also appeared incredible that no specimens of intervening forms should have been preserved in the rocks representing the great time-gap between the Ordovician and Jurassic formations.

In this connexion Professor Seward remarks[4]: "It is reasonable to prophesy that further researches into the structure of ancient limestones will considerably extend our knowledge of the geological and botanical history of the Corallinaceæ." This prophecy has been amply fulfilled, especially as regards this particular genus, and recent discoveries go far towards filling the previously existing gaps in our knowledge of the vertical distribution of this interesting genus.

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[1] GEOL. MAG., Dec. III, Vol. V, p. 19, 1888.

[2] GEOL. MAG., Dec. III, Vol. II, p. 534, 1885.

[3] GEOL. MAG., Dec. IV, Vol. I, pp. 145 and 195, 1894.

[4] *Fossil Plants*, vol. i, p. 190, 1898.

Thus the recent detection in the lowest Cambrian rocks of the Antarctic Continent of a form which appears to be referable to this genus enables us to trace the ancestry of *Solenopora* back almost to the earliest rocks in which fossils have yet been discovered, while the gap in the succession which previously existed between the Ordovician and Jurassic forms was decreased by the description in 1908 by Professor Rothpletz of a new species *Solenopora gotlandica*, from the Silurian rocks of Faröe Islands in Gotland.[1] A large number of deposits, however, still remained, between the Gotlandian and Lower Jurassic beds, from which no example of *Solenopora* had so far been recorded.

The identification, therefore, a few years ago, by Dr. G. J. Hinde, of examples of this genus from among the nodules I had collected from the Shap dolomites, is of considerable interest, as the presence of *Solenopora* in the Lower Carboniferous rocks of this country materially decreases the gap in our knowledge of the succession of forms belonging to this genus which had previously existed.

Girvanella.

This organism, which is now known to be widely distributed in the Palæozoic and Mesozoic rocks of this country, was originally described in 1878 by Nicholson and Etheridge, jun., from the Ordovician rocks of the Girvan district. The genus was established to include certain small nodular structures composed of a felted mass of interlacing tubes, having a width of 10 and 18 μ, the cells being typically simple, imperforate tubes without visible internal partitions. The geno-type, *G. problematica*, was, however, at that time referred to the Rhizopods and regarded as related to the arenaceous foraminifera.[2] In 1888 Nicholson, in redescribing this genus in the Geological Magazine, compares *Girvanella* with the recent form *Syringammina fragillissima* of Brady.

More recently Mr. Wethered has shown that an intimate association frequently exists between *Girvanella* tubes and oolitic structure, and he has described several new species of *Girvanella* from the Palæozoic rocks and also from certain Jurassic limestones.

The reference of *Girvanella* to the Calcareous Algæ, though not yet supported by incontestable evidence, has been advocated by several writers in recent years. Even as long ago as 1887, Bornemann, in describing examples of *Siphonema* (*Girvanella*, Nich.) which he had discovered in the Cambrian rocks of the Island of Sardinia, suggested that this organism might belong to the Calcareous Algæ.

In 1891 Rothpletz[3] noticed that some of the specimens of *Girvanella* which he had examined were characterized by dichotomous branching of the tubes; on this account he removed the genus from the Rhizopods to the Calcareous Algæ, placing it provisionally among the Codiaceæ. Three years later Dr. A. Brown, in summing up the evidence in favour of the inclusion of *Solenopora* among the Nullipores, expressed the opinion that *Girvanella* might ultimately come to be regarded as referable to the Siphoneæ Verticillatæ.

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[1] *Kungl. Svenska, Vets. akad. Handl.*, Bd. 43, No. 5, pl. iv, pp. 1–5 and 14, 1908.

[2] *Silurian Fossils in the Girvan District*, 1878, p. 23.

[3] Zeitschr. d. D. Geol. Gesell., 1891.

In 1898, however, this genus was still only doubtfully placed with the Calcareous Algæ, for Seward, in his work on *Fossil Plants*,[1] remarks: "The nature of *Girvanella*, and still more its exact position in the organic world, is quite uncertain. . . . We must be content for the present to leave its precise nature still *sub judice* and, while regarding it as probably an alga, we may venture to consider it more fittingly discussed among the Schizophyta than elsewhere."

In 1908, however, Rothpletz, in discussing the relationship of *Spherocodium* and *Girvanella*, reaffirms his opinion that the latter must be referred to the Codiaceæ.[2]

Mitcheldeania.

This genus was first described by Mr. Edward Wethered from the Lower Carboniferous beds of the Forest of Dean[3] under the name of *Mitcheldeania Nicholsoni*; it was referred by him to the Hydractinidæ, and considered to be allied to the Stromatoporoids. The figure accompanying this paper unfortunately fails to show any of the characters of the organism, but a better figure of the same species was subsequently published in the Proceedings of the Cotteswold Naturalists' Field Club.[4]

In 1888 Professor H. A. Nicholson published in the Geological Magazine[5] figures and descriptions of a new species of this genus (*M. gregaria*), and redefined the genus as having "the form of small, rounded or oval calcareous masses made up of capillary tubes of an oval or circular shape, which radiate from a central point or points, and are intermixed with an interstitial tissue of very much more minute branching tubuli". He compares the larger tubes to zooidal tubes, and states that they "communicate with one another by means of large, irregularly-placed foramina resembling 'the mural pores' of the Favositidæ, and they occasionally exhibit a few irregular transverse partitions or tubulæ".

With regard to the systematic position of this genus Nicholson remarks: "In spite of the extreme minuteness of its tissues, the genus *Mitcheldeania* may, I think, be referred with tolerable certainty to the Cœlenterata . . . its closest affinities seem to be with the Hydrocorallines . . . on the other hand all the known Hydrocorallines possess zooidal tubes which are enormously larger than those of *Mitcheldeania*; and there are other morphological features in the latter genus which would preclude its being actually placed, with our present knowledge, in the group of the *Hydrocorallinæ*."

Since this description by Professor Nicholson no further account of this organism, so far as I am aware, has been published, and its reference to the *Hydrozoa* rests on Professor Nicholson's description.

During the past few years I have collected a large amount of material from both of the type localities from which Mr. Wethered and Professor Nicholson obtained their specimens, and an examination of this material has impressed me strongly with the resemblance of *Mitcheldeania* to forms such as *Solenopora* and *Girvanella*, now usually classed among the Calcareous Algæ. In the rocks in which it occurs *Mitcheldeania* appears as rounded and lobulate nodules, breaking with porcellanous fracture and showing concentric structure on weathered surfaces, very similar to nodules of *Solenopora*; while under the microscope the branching character of the tubules and their comparatively minute size appear to separate them from the Monticuliporoids. Professor Nicholson appears to rely on the presence of pores, which he thought he observed in the walls of both the larger and finer tubes, for the inclusion of this genus with the Hydrocorallines, though he appeared to be doubtful about their occurrence in the interstitial tubuli. An examination of a large number of slides has failed to convince me of the presence of pores, even in the larger 'zooidal tubes'. The large 'oval or circular' apertures noticed by Nicholson appear to be either elbows in the undulating tubes cut across where these bend away from the plane of the section, or places where a branch is given off from a tube at an angle to the plane of the section. If this view be accepted, there appears to be no sufficient reason why *Mitcheldeania* should not be ranged with *Solenopora* and other similar forms, and included among the Calcareous Algæ—a position which its mode of occurrence and general structure has led me, for some time, to assign to this organism.

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[1] Op. cit., vol. i, p. 125.

[2] Rothpletz, Kungl. Sven. Vets. Akad. Hardl., Bd. 43, No. 5, loc. cit., 1908.

[3] Geol. Mag., Dec. III, Vol. III, p. 535, 1886.

[4] Vol. ix, p. 77, pl. v, 1886.

[5] Op. cit., p. 16.

In addition to the three chief forms described above from British rocks, a study of numerous thin sections from the Lower Carboniferous rocks of the north-west of England has revealed the presence of several distinct organisms, which will, I think, eventually be found to be referable to the Calcareous Algæ.

This meagre list appears to exhaust the genera known at the present time from the Lower Carboniferous rocks of Britain, while the only additional genus so far recorded from the Mesozoic and Tertiary rocks of this country (if we accept Rothpletz's sub-genus *Solenoporella*) is *Chara* from the Wealden beds of Sussex, the uppermost Jurassic of the Isle of Wight and Swanage, and the Oligocene of the Isle of Wight.

Outside this country the literature on fossil Calcareous Algæ is much more extensive. The interest originally aroused on the Continent by the writings of Philippi, of Unger of Vienna, Cohn, Rosanoff, Gümbel, Saporta, and Munier-Chalmas, has been further maintained in our own time by Bornemann, Steinmann, Früh, Solms-Laubach,[1] Rothpletz, Walther, Kiaer, and others; while the more favourable conditions which obtained for the growth of these organisms, especially during Silurian, Triassic, and Tertiary times, has afforded a much wider field for their observation.

Thus, in addition to the forms recorded from this country, an important part has been played by members of the family of the Dasycladaceæ, together with such genera as *Spherocodium*, *Lithothamnion*, and *Lithophyllum*.

(*To be continued in our next Number.*)

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[1] *Fossil Botany* (Oxford), 1891.

Sandstone Series of North-Western Spitzbergen" gave the following correlation :—

Spitzbergen.	*Thickness.*	*Scotland.*
Wijde Bay Series	2,000 metres	Upper Old Red.
Grey Hoek Series	2,000 ,,	Middle Old Red (Orcadian).
Wood Bay Series	2,500 ,,	Lower Old Red (Caledonian).
Red Bay Series	2,300 ,,	Downtonian.

For want of guide fossils in the Grey Hoek Series its contemporaneity with the Middle Old Red is not proved. A paper on Periodicity of Palæozoic orogenic movements by T. C. Chamberlin and R. T. Chamberlin was also read. Six papers on tectonics and many miscellaneous papers were contributed, among which two papers on the geology of Argentina, by H. Keidel and Bailey Willis respectively, deserve special mention.

No account of the meeting of the Geological Congress in Canada would be complete without a reference to the excursions, which were to many the most attractive feature. Twelve excursions were arranged to take place before the meeting. The chief of these were that to Quebec and the Maritime Provinces, led by G. A. Young, J. M. Clarke, E. R. Faribault, etc., occupying nineteen days; that to Haliburton–Bancroft (Ontario), conducted by F. D. Adams and A. E. Barlow, seven days; and that to Sudbury–Cobalt–Porcupine (Ontario), led by W. G. Miller, ten days. Ten short excursions took place during the meeting and nine excursions after the meeting. The chief of these were the two great transcontinental excursions, C 1, by the Canadian Pacific main line over the Kicking Horse Pass to Victoria, Vancouver Island, and back, twenty-three days, and C 2, by the Crow's Nest Pass to the same place and back, twenty-three days, and last, but not least, C 8, to Yukon and Malaspina and back, twenty-five days. The excursions were splendidly organized, and in connexion with them guidebooks, in ten sections, divided into thirteen handbooks, were prepared. These comprised a total of 2,012 pages, illustrated by 154 maps, mostly coloured, 41 sections or drawings, and 281 process reproductions of photographs. They not only summarize pre-existing knowledge, but contain much new material.

If in this short account little has been said of the public functions, such as the conferring of honorary degrees and the unveiling at Percé and at Ottawa of memorial tablets to Sir William Logan, strict limitations of space must be the writer's excuse.

III.—ON THE IMPORTANT PART PLAYED BY CALCAREOUS ALGÆ AT CERTAIN GEOLOGICAL HORIZONS, WITH SPECIAL REFERENCE TO THE PALÆOZOIC ROCKS.

By Professor E. J. GARWOOD, M.A., V.P.G.S.[1]

(*Continued from the October Number, p. 446.*)

IT is now time to turn to the consideration of the part played by these organisms in the formation of sedimentary rocks through the successive geological periods.

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[1] Edited and slightly abridged with the author's permission from the original Address as delivered at Birmingham, before Section C at the British Association meeting.

ARCHÆAN.

In the Archæan rocks no undoubted remains of Calcareous Algæ have yet, so far as I am aware, been recorded, but Sederholm considers that certain small nodules in the Archæan schists of Finland may represent vegetable remains. I may also perhaps here refer to some curious oolitic structures which I met with in Spitzbergen in 1896 when examining the rocks of Hornsund Bay. These oolites occur on the south side of the bay, and are closely connected with massive siliceous rocks which may represent old quartzites. The whole series is much altered, and detailed structure cannot now be made out. The rocks occur apparently stratigraphically below the massif of the Hornsund Tinde, and may belong either to the Archæan or the base of the Heckla Hook Series. As, however, similar rocks have not been recorded from the type district of Heckla Hook, they may be referred provisionally to the Algonkian, and may represent the quartzites and earthy limestone of the Jotnian Series of Scandinavia. They are mentioned here in connexion with Mr. Wethered's view that oolites are essentially associated with the growth of *Girvanella.*

CAMBRIAN.

Passing on to the Palæozoic rocks, we find in the Cambrian deposits but few indications that Calcareous Algæ played any considerable part in their formation.

This is no doubt due, to some extent, to the conditions under which these deposits accumulated in the classical localities where true calcareous deposits are typically absent. In the Durness Limestone, however, where considerable masses of dolomites occur, the conditions would appear at first sight to have been more suitable for the growth of these organisms; but even here the slow rate of accumulation and the large amount of contemporaneous solution may have militated against their preservation. At the same time, it is possible that a systematic search in the calcareous facies of the Cambrian rocks in the North of Europe and America may result in the discovery of the remains of some members of this group. That there is ground for this suggestion is shown by recent work in the Antarctic Continent.

Professor Edgeworth David and Mr. R. E. Priestley have discovered among the rocks on the north-west side of the Beardmore Glacier dark-grey and pinkish-grey limestone containing the remains of Archæocyathinæ, Trilobites, and sponge spicules, together with abundant remains of a small calcareous alga referred provisionally to *Solenopora.* From the photographs exhibited by Professor David on the occasion of his lecture (February 8, 1911) to the Geological Society, I have little doubt that this reference is correct.

A further occurrence of *Solenopora* is also reported from fragments of a limestone breccia collected by the Southern party from the western lateral moraine of the same glacier. Speaking of the fauna discovered in this limestone Professor David remarks: "The whole assemblage is so closely analogous with that found in the Lower Cambrian of South Australia as to leave no doubt as to the geological age of the limestones from which these fragments are derived."[1] This discovery, therefore, extends the vertical range of this widely distributed genus down to the oldest Palæozoic rocks. It is interesting to note that the rocks in which the *Solenopora* occurs on the Antarctic Continent contain a development of pisolite and oolite, and that this is also the case in the Australian equivalents. In 1887 and again in 1891 Bornemann described and figured species of *Siphonema* and *Confervites*[1] from the *Archæocyathus* limestones of Sardinia. As regards the former genus, it was shown by Dr. Hinde[2] to be congeneric with *Girvanella* (Nich. & Eth.). It is of interest, however, to note that Bornemann describes this form as a calcareous alga, and compares it with existing subaerial Algæ growing on the surface of limestone rocks in Switzerland. The latter genus is stated by Seward to be possibly "a Cambrian alga, but the figures and descriptions do not afford by any means convincing evidence" (*Fossil Plants*, vol. i, p. 178).

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[1] Eleventh Internat. Geol. Congress Report, 1910, p. 775.

More recently, in 1904, Dr. T. Lorenz[3] has described remains of *Siphoneæ* from the Cambrian rocks of Tschang-duang in Northern China, for which he erects two new genera, *Ascosoma* and *Mitscherlichia*, placing them in a new family, the Ascosomaceæ. These Algæ build important beds of limestone, the individuals often attaining a length of 4 cm. and a thickness of 1·5 cm. In 1907 Bailey Willis[4] reported *Girvanella* associated with oolites in the lowest Cambrian Man-t'o Beds in China. It is probable, therefore, that as our knowledge of these rocks is extended, Calcareous Algæ will be found to play an important part in the Cambrian limestones of the Asiatic Continent and Australia.[5]

ORDOVICIAN.

In the Ordovician rocks the remains of Calcareous Algæ become much more abundant; they are very widely distributed and for the first time they become important rock-builders. In Britain the chief genera met with are *Girvanella* and *Solenopora*. These two organisms occur abundantly in the Scottish Ordovician rocks of the Girvan area, where they appear to have contributed largely to the limestones of the Barr Series in Llandeilo–Caradoc times.

As already mentioned, *Girvanella problematica* was originally described by the late Professor Nicholson and Mr. R. Etheridge, jun., from the Craighead Limestone at Tramitchell, where it occurs in great numbers. The officers of the Geological Survey also report it from the Stinchar Limestone of Benan Hill.[6] It occurs in the form of small rounded or irregular nodules, varying in diameter from less than a millimetre to more than a centimetre, many of the nodules showing marked concentric structure. In Benan Burn, where these beds are admirably exposed, the *Girvanella* nodules appear conspicuously on the weathered surfaces, being so abundant as to constitute thick layers of limestone.

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[1] Nova Acta Cæs. Leop. Car., 1887 and 1891.

[2] Hinde, GEOL. MAG., Dec. III, Vol. IV, p. 226, 1887.

[3] Centralb. f. Min., 1904, p. 193.

[4] *Research in China*, 1907.

[5] Chapman, Proc. Roy. Soc. Vict., 1911, p. 308.

[6] *The Silurian Rocks of Britain*, vol. i, Scotland (Mem. Geol. Surv. U.K.), pp. 487, 494, 496, 500.

Solenopora compacta, var. *Peachii*, which likewise forms important masses of limestone, is found, like *Girvanella problematica*, most abundantly in the Girvan area, but at a somewhat lower horizon, namely, in the 'nodular limestone' and shales forming the lower subdivision of the Stinchar Limestone. The horizon of the Stinchar Limestone is correlated by Professor Lapworth with the Craighead Limestone, and considered to represent the summit of the Llandeilo or the base of the Caradoc rocks of the Shropshire district. It is of interest to note that *Solenopora* is here accompanied at times by well-marked oolitic structure, and that the same is true of the pebbles with which it is associated in the conglomerate at Habbie's Howe.

Although the marked development of *Solenopora* found in the Stinchar Limestone ceases with the advent of the Benan conglomerate, the genus appears to have survived in the Girvan district into Upper Caradoc times, for Dr. Brown describes a new species (*S. lithothamnioides*) from Nicholson's collection from the Ordovician (? Silurian) beds at Shalloch Mill, where it is said to occur in conical masses the size of a walnut. Specimens of *Solenopora* from Shalloch Mill in Mrs. Gray's collection were obtained from Professor Lapworth's Whitehouse Group.

South of the Scottish border there is, so far as I am aware, only one locality from which Calcareous Algæ have been recorded in rocks of Ordovician age, namely, Hoar Edge in Shropshire. Here large examples of *Solenopora compacta* were obtained in 1888 by Professor Lapworth from the calcareous layers near the base of the Hoar Edge Sandstone. The specimens were handed to Professor Nicholson, who records the circumstance in his description of *S. compacta* in 1888.[1] The form occurs here at the base of the Caradoc beds, and therefore at an horizon which corresponds closely to that of the Craighead Limestone of Girvan.

Professor Lapworth also informs me that he has obtained specimens of *Solenopora* from a limestone in south-west Radnorshire. As the upper portion of the limestone in which it is found contains a Silurian fauna, it is possible that it is here present at a higher horizon, though the constancy with which it occurs elsewhere, in beds of Llandeilo–Caradoc age, would seem to point to the possibility that beds of Upper Ordovician age are also present in this area. In any case its occurrence here is of considerable interest.

Foreign Ordovician.

Outside of Britain the most important development of Calcareous Algæ in rocks of Ordovician age is found in the Baltic Provinces.

Solenopora occurs here in the Upper Caradoc or Borckholm Beds of Schmidt's classification—where it makes up thick beds of limestone—and it is noteworthy that this horizon is practically identical with that at which *S. lithothamnioides* (Brown) occurs at Shalloch Mill.

Other specimens of *Solenopora* were collected by Professor Nicholson in Saak, south of Reval, from the underlying Jewe Beds, an horizon which must correspond very closely to that of the Craighead Limestone of Girvan. Speaking of these beds Nicholson & Etheridge remark: "At this locality *S. compacta* not only occurs as detached specimens of all sizes, but it also makes up almost entire beds of limestone; indeed, some of the bands of limestone at Saak look like amygdaloidal lavas, while others have a cellular appearance from the dissolution out of them of the little pea-like skeletons of this fossil."[1]

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[1] GEOL. MAG., Dec. III, Vol. V, p. 22, 1888.

In Professor Nicholson's collection from these beds Dr. Brown[2] afterwards distinguished two new species, namely, *S. nigra* and *S. dendriformis*. Thus, in the Ordovician rocks of Esthonia, *Solenopora* plays quite as important a part (as a rock-forming organism) as it does in the Girvan district in Ayrshire.

In Norway, again, in the Mjösen district to the north of Christiania, *Solenopora* occurs plentifully in Stage 5 of Kiær's[3] Ordovician series. Here it is very abundant and often builds entire beds, while, further east, at Furnberg, Kiær again records the occurrence of abundant nodules of *Solenopora compacta*, var. *Peachii*.

In addition to *Solenopora*, however, examples of another important group of Calcareous Algæ, the Siphoneæ, occur in great abundance in the Ordovician rocks of the Baltic region, where they play a part in the formation of calcareous rocks scarcely less important than that played by *Gyroporella* and *Diplopora* in the rocks of the Alpine Trias.

The chief forms belong to the family of the Dasycladaceæ, which is represented in our present seas by the recent genus *Neomeris*; they include the genera *Palæoporella*, *Dasyporella*, *Rhabdoporella*, *Vermiporella*, *Cyclocrinus*, and *Apidium*. These algal limestones represent the horizons from the Jewe Limestone to the Borckholm Beds inclusive. They were originally investigated by Dr. E. Stolley,[4] who described their occurrence in the numerous boulders which are strewn over the North German plain in Schleswig-Holstein, Pomerania, Mecklenburg, and Mark-Brandenberg. The facts appear to show that during the deposition of the Jewe and the overlying Wesenberg and Lyckholm Limestones an algal facies obtained which extended from Oeland to Estland, and as far north as the Gulf of Bothnia. But even this area does not represent the full extent of the algal limestone facies in the North of Europe in Upper Ordovician times. In Norway, Kiær[5] has shown by his detailed work in the Upper Ordovician rocks (Stage 5) of the Christiania district, the important part played by the Dasycladaceæ in this area. Here the Gastropod limestone in places forms a 'phytozoan limestone', made up of *Rhabdoporella*, *Vermiporella*, and *Apidium*, associated with a considerable development of oolite.

Again, at Kuven and Valle, in the Bergen district, Reusch[6] and

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[1] Geol. Mag., Dec. III, Vol. II, p. 534, 1885.

[2] Geol. Mag., Dec. IV, Vol. I, p. 145 et seqq., 1894.

[3] "Faunistische Uebersicht d. Et. 5": Vid. Selsk. Skr., 1897, No. 3.

[4] Schr. d. naturw. ver. f. Schleswig-Holstein, Bd. xi, 1897, and references there given.

[5] Etage 5 i. Asker. Norges Geol. undersogeles Aarbog, 1902, No. 1.

[6] *Silurfossiler og pressede Konglomerate*, 1882. "*Bømmeløen og Karmøen*": Med. omgiveleser, 1888.

Kolderup[1] have described knolls of crystalline limestone containing abundant remains of *Rhabdoporella* (formerly described as *Syringophyllum*) associated with a Gastropod and coral fauna.

We have, therefore, in Upper Ordovician times, in the North of Europe, one of the most remarkable developments of algal limestones met with throughout the geological succession. In North America Calcareous Algæ are represented in Ordovician times by *Solenopora compacta*, which occurs in the Trenton and Black River Limestone groups, whence it was originally described by Billings under the name *Stromatopora compacta*. It therefore occurs in America at about the same horizon as in Saak and Britain.

We may also note the occurrence of *Girvanella* in the underlying Chazy Limestone. This occurrence was originally described by the late Professor H. G. Seeley[2] under the name of *Strephochetus ocellatus*, but is now generally admitted to be a species of *Girvanella*.[3]

Other forms referred to this genus have also been reported by Schuchert from rocks of undoubted Ordovician age on the east coast of the Behring Straits.[4]

SILURIAN.

In Britain the only horizon of Silurian age at which Calcareous Algæ play an important part is the Wenlock Limestone. Some years ago Mr. Wethered described the occurrence of *Girvanella* tubes in the beds of this age, especially at May Hill, Purley, near Malvern, and near Ledbury.[5]

Foreign Silurian.

Outside of Britain, however, we find at this period a marked algal development, and this again occurs in the Baltic area, where, especially in the island of Gotland, algal growths contribute largely to several of the limestones and marls. It is an interesting fact that very shortly after the disappearance of the various members of the Dasycladaceæ which were so much in evidence in Ordovician times, we should have the remarkable development of another group of the Siphoneæ, which, quickly reaching a maximum, built up in their turn abundant calcareous deposits. Nodules from these limestones have long been known from Gotland under the name of 'Girvanella Rock', and have been recorded by Stolley[6] in boulders scattered over the North German plain. In 1908, however, Professor Rothpletz showed, in his interesting work on these Gotland deposits,[7] that the forms hitherto alluded to under the term '*Girvanella*' were in reality referable to two different genera. One of these he showed to be a new species of *Solenopora*, to which he gave the name *S. gotlandica* (distinguished from *S. compacta* by the comparatively small dimension of the tubes, which are only about one-quarter of the diameter of the latter species); the other he referred to his genus *Spherocodium*, which he had created in 1890 for certain forms from the Alpine Trias.[1] The survival here of *Solenopora* into beds of undoubted Silurian age is an interesting fact, and would lead us to expect that it may also some day be met with in rocks of a corresponding age in Britain.

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[1] *Et orienterende niveau Bergenskiffe, Rhabdoporellenkalk von Kuven und Valle*, Bergens Museums, Aarbog, 1897.

[2] Am. Journ. Sci., vol. xxx, p. 355, 1885.

[3] GEOL. MAG., Dec. III, Vol. IV, p. 226, 1887.

[4] See Haug, vol. ii, pt. i, p. 643.

[5] Q.J.G.S., vol. xlix, p. 236, 1893.

[6] Schr. d. naturw. ver. f. Schleswig-Holstein, Bd. xi, 1897, and references there given.

[7] Kungl. Svenska Vet. Akad. Handl., Bd. xliii, No. v, 1908.

Of the different forms of Algæ which occur in these Gotlandian deposits, perhaps the most interesting is *Spherocodium*, which, as shown by Dr. Munthe,[2] occurs at several horizons in the succession. It first makes its appearance in the marl immediately overlying the Dayia Flags — approximately of Lower Ludlow age — where it occurs in considerable masses. In external appearance these resemble very closely nodules of *Ortonella* from the Lower Carboniferous rocks of the North-West of England; some of the nodules appear to have reached a diameter of 4 cm. The marl is overlain by sandstone and oolite, which are succeeded by an argillaceous limestone rich in nodules of *Spherocodium gotlandicum* and well exposed at Grötlingbo, where it is closely associated with oolite. Among the fossils of this limestone *Spherocodium* itself plays the most important rôle.

In the overlying 'Iliona Limestone' *Spherocodium* is decidedly rare, and its place is taken by *Spongiostroma*. As will be pointed out later, there appears to be no good reason why *Spongiostroma* may not be indirectly due to the presence of algal growths; but whatever may be the final position assigned to it, there can be no doubt as to its importance as a rock-building form in the Iliona Limestone of Gotland. We may conclude, therefore, that the development of the *Spherocodium* beds of Gotland probably occupied originally nearly as wide an extension in the Baltic area as did the *Rhabdoporella* limestones during the Ordovician Period.

With regard to other occurrences of Calcareous Algæ in Silurian rocks, it will be sufficient to note that of *Girvanella* in the Silurian limestones of Queensland, recorded by Mr. G. W. Card in 1900,[3] and more recently by Mr. Chapman from Victoria.[4]

Quite recently Mr. R. Etheridge, jun., of Sydney,[5] has described "an organism allied to *Mitcheldeania* from the Upper Silurian rocks of New South Wales"; the figures given, however, and the description are not convincing that his identification can be accepted. The size of the tubes, which are from five to six times as large as those of *M. gregaria*, would alone appear to remove this organism from Mr. Wethered's genus and also possibly from the Calcareous Algæ.

DEVONIAN.

So far as I am aware, there is only one recorded occurrence of Calcareous Algæ from the Devonian rocks of Britain—namely, in the Hope's Nose Limestone of Devonshire, from which Mr. Wethered has described aggregations of tubules resembling *Girvanella*, but in a very poor state of preservation.

[1] Bot. Cent., vol. lii, p. 9, 1890.

[2] Geol. Foren. Forh. Stock., Bd. xxxii, Hft. v, p. 1397, 1910.

[3] Bull. Geol. Surv. Queensland, 1900, No. 12, pp. 25–32, pl. iii.

[4] Rep. Austr. Assoc. Adv. Sci., 1907–8, pp. 377–86, pls. i–iii, 1908.

[5] Rec. Geol. Surv. N.S. Wales, vol. viii, pt. iv, p. 308, pl. xlvii, 1909.

Foreign Devonian.

On the Continent the reported occurrences are, so far, equally poor. At the same time, the cursory examination which I was able to make of the thin sections of the Devonian limestones exhibited in the Brussels Museum leads me to expect that a careful investigation of the Belgian Devonian limestones will yield other examples besides *Spongiostroma*.

CARBONIFEROUS.

We now reach the period in Palæozoic times when Calcareous Algæ attained their maximum development in England, a development rivalling that which obtained in the Ordovician rocks of Scotland and the Gotlandian of the Baltic area. The genera represented include *Girvanella*, *Solenopora*, and *Mitcheldeania*, while in addition to these there occur several lime-secreting organisms which, though still undescribed, will, I think, ultimately come to be included among the Calcareous Algæ. The most interesting of these organisms I have recently figured from the Lower Carboniferous rocks of Westmorland, where it forms a definite zonal horizon or 'band'.[1] For this form, on account of its stratigraphical importance and for facility of reference, I propose the generic name of *Ortonella*.[2]

Again, at the same horizon in the North-West Province I have frequently noticed concretionary deposits of limestone which occur as finely laminated masses, the laminæ often lying parallel to the general direction of the bedding planes, which on microscopic examination show no definite or regular structure, but have every appearance of being of organic origin. Many of these puzzling forms resemble very closely the somewhat obscure structures found in the Visean limestones of the Namur basin in Belgium, of which beautiful thin sections are displayed in the Natural History Museum at Brussels,[3] and which Gürich has described and figured under various names—*Spongiostroma*, *Malacostroma*, etc., and which he has included under a new family, the Spongiostromidæ,[4] and a new order, the Spongiostromaceæ. I must confess that neither in the original sections nor in the beautiful illustrations that accompany his work can I see any grounds for referring these structures to the Protozoa.

As regards the British specimens, I have long regarded them as due, directly or indirectly, to the work of Calcareous Algæ, partly on account of their intimate association with well-developed examples of these organisms and also on account of the entire absence of Foraminifera and other detrital organisms wherever this structure occurs. As, however, I have little doubt that they are closely connected in their mode of origin with the Belgian specimens, we may conveniently speak of them under the general term *Spongiostroma*.

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[1] Q.J.G.S., vol. lxviii, pl. lxvii, fig. 2, 1912.

[2] From Orton, a village between Shap and Ravenstonedale, where this organism occurs in great abundance.

[3] One of these is also exhibited at the Jermyn Street Museum.

[4] Mém. du Musée Roy. d'Hist. Nat. de Belgique, tom. iii, 1906.

Some of the best examples known to me occur associated with *Ortonella* in the '*Productus globosus* band' near the summit of the '*Athyris glabristria* zone' in the Shap district. They occur here in considerable masses, often many inches in thickness, and form undulating layers parallel to the bedding, and somewhat resembling large ripple-marks. In all cases they appear to be due to the precipitation of carbonate of lime in the neighbourhood of algal growths. I have also met with similar deposits, not only at other horizons in the Lower Carboniferous rocks of the North of England, but also in the Forest of Dean and in the rocks of the Avon Gorge; while quite recently Mr. C. H. Cunnington has sent me examples from several horizons in the Carboniferous Limestone of South Wales.

Girvanella.—This organism appears to play a considerable part in the formation of calcareous deposits in the Lower Carboniferous rocks of Britain. Its presence in these rocks was first suggested by the late Professor Nicholson,[1] who wrote: "I have found some of the Carboniferous Limestone of the North of England to contain largely an ill-preserved organism, which will, I think, prove to be referable to *Girvanella*." This prophecy has turned out to be fully justified, not only as regards the North of England, but also in the case of the Lower Carboniferous beds of other districts. In 1890 Mr. E. Wethered described[2] two new forms of this genus from the Lower Carboniferous rocks of the Avon Gorge and Tortworth, viz. *G. incrustans*, with tubes having a diameter of 0·1 mm., and *G. Ducii*, with a diameter of ·02 mm. Mr. Wethered appears to rely chiefly on the size of the tubes for the differentiation of these species, but as this distinction was made at the time when *Girvanella* was still considered to belong to the Rhizopods, and as the size of the tubes frequently varies in the same specimen, it is doubtful whether these species can be maintained. Mr. Wethered's specimens were obtained from the limestone near where the Bridge Valley Road joins the river bank, apparently at the base of Dr. Vaughan's Upper Dibunophyllum Zone. The position of this limestone is of interest, as it appears to correspond very closely with the horizon of the '*Girvanella* Nodular Bed', which forms a well-marked band at the base of the Upper Dibunophyllum Zone throughout the whole of the North and North-West of England. Indeed, I have traced this band at intervals from the neighbourhood of Ford, near the Scottish Border, southwards through Northumberland and the Pennine area to Penygent, and from the west coast at Humphrey Head through Arnside and Shap to the east coast near Dunstanburgh. These organisms must, therefore, have flourished at this period over an area of at least 3,000 square miles in the North of England alone.

The best exposure showing the important development of these *Girvanella* nodules is to be found on the dip slopes forming the eastern shore of Humphrey Head in Morecambe Bay, where the base of the Upper Dibunophyllum Zone is exposed over a considerable area.

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[1] GEOL. MAG., Dec. III, Vol. V, 1888.

[2] Q.J.G.S., vol. xlvii, p. 280, pl. xi, figs. 1, 2, 1890.

(*To be concluded in the December Number.*)

Obviously, we have here an intrusion of the same nature as the diorite intrusion of Garabal Hill, but differing from the latter by the fact that part has undergone more rapid cooling, and hence has formed the diorite-porphyry. Analogous rocks, however, occur in the Strath Dubh Uisge valley, where a few dykes of very decomposed felspar-porphyry outcrop. An occurrence of diorite apparently passing to porphyrite has been described from Loch Melfort,[1] but the Geological Survey are of the opinion that the porphyrite is an earlier intrusion which has been altered by the diorite. In the island of Colonsay intrusions of augite-diorites have been found, grading to lamprophyres on the margins.[2] The junctions of the different types in Glen Lednock are very obscure, and hence the relations between the rocks cannot be ascertained.

IV.—On the Important Part played by Calcareous Algæ at certain Geological Horizons, with Special Reference to the Palæozoic Rocks.

By Professor E. J. Garwood, M.A., V.P.G.S.[3]

(*Concluded from the November Number, p. 498.*)

(WITH FOLDING TABLE II.)

Solenopora.—The discovery of this genus in the Lower Carboniferous rocks of Westmorland is of considerable interest, as its occurrence here gives us some insight into the history of its wanderings between the time when we last recorded it in the Gotlandian rocks of the Baltic area and its subsequent reappearance in the Lower Oolite of Gloucestershire. Whether it lived in the Baltic area during the Devonian and Carboniferous periods is, however, still unknown. The fact of its occurrence in the Caradoc, Carboniferous, and Jurassic rocks of the British Isles would appear to point to its existence not far off during the intervening periods.

In Westmorland and Lancashire *Solenopora* occurs in considerable abundance near the local base of the Lower Carboniferous rocks, and contributes largely to the formation of limestone deposits. It is present wherever the lowest beds of the succession are exposed, as at Shap, Ravenstonedale, and Meathop, and must formerly have flourished over a considerable area.

Though bearing a general resemblance, both in hand specimens and in microscopic structure, to the Ordovician and Jurassic forms, it has recently been shown by Dr. G. J. Hinde to be specifically distinct.[4] It occurs as small, spheroidal nodules up to an inch in diameter, having a markedly lobulate outline embedded in compact and usually dolomitic limestones, and it is occasionally associated with oolitic structure. When fractured it exhibits the compact porcellanous texture and pale brownish tint characteristic of other species of this genus, while weathered surfaces frequently show a concentric and occasionally a radially fibrous structure. The profusion of this form in Westmorland would lead one to expect its occurrence in other districts where the lowest Carboniferous zones are developed; but so far as I am aware, no such occurrence has yet been recorded. It may be of interest, therefore, to mention here that a few years ago my friend Mr. P. de G. Benson brought me a specimen of rock from near the base of the succession in the Avon Gorge, which on cutting I found to contain several examples of *Solenopora* identical with the Westmorland form.

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[1] Flett in *Geology of Oban and Dalmally* (Mem. Geol. Surv. Scotland), 1908, p. 69.

[2] Wright & Bailey, loc. cit., pp. 33–4.

[3] Edited and slightly abridged with the author's permission from the original Address as delivered at Birmingham, before Section C at the British Association meeting.

[4] Geol. Mag., Dec. V, Vol. X, p. 289, 1913.

Mitcheldeania.—The specimens of *Mitcheldeania Nicholsoni* originally described by Mr. Wethered were obtained from Wadley's Quarry, near Drybrook, Mitcheldean, from the Lower Limestone shales near the base of the succession. Professor Sibly, who has recently made a careful study of the Lower Carboniferous succession in the Forest of Dean,[1] has traced this algal layer over a considerable area, and considers it to represent an horizon near the top of K.II. of the Bristol sequence. He has also noted examples of *Mitcheldeania* at a higher level—namely, in the Whitehead Limestone, an horizon corresponding probably to the base of C.2. During a recent visit to the Mitcheldean district I collected specimens from the lower shales and also from the Whitehead Limestone, and, thanks to Professor Sibly's kind directions, I was able to see numerous sections in which he has found this algal development. There can be no doubt that *Mitcheldeania* is here an important rock-forming organism at least at two horizons in this district, and that it occurs over a considerable area. Interesting as the development of *Mitcheldeania* in the Forest of Dean undoubtedly is, its real home in Britain is in North Cumberland and along the Scottish Border, where it flourished to a remarkable extent in the shallow-water lagoons which spread over so large an area in the North of England during early Carboniferous times. Over the greater part of North Cumberland and the east of Roxburgh we find a remarkable development of algal limestones in the formation of which *Mitcheldeania* plays a very important part. It is met with especially at two horizons—an upper one, lying immediately below the Fell Sandstone, and a lower one in the middle of the underlying series of limestone and shales. The lower horizon is especially interesting on account of the thick masses of limestone composed almost entirely of algal remains. Though *Mitcheldeania* forms the basis of this reef-like development, it is accompanied by other algal forms, especially bundles of the minute tubules of *Girvanella* together with coarser tubes reminding one of the *Sphærocodium* deposits of Gotland; in places again the marked concentric coatings resemble certain forms of *Spongiostroma*. The substance of the reef has frequently formed round the remains of Orthoceratites—indeed, the chief layer is usually associated with remains of these Cephalopoda. With other layers occur tubes of *Serpulæ* and remains of Ostracoda. In addition to the limestone of this massive reef, abundant nodules of *Mitcheldeania* lie scattered through the calcareous shales both above and below.

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[1] Geol. Mag., Dec. V, Vol. IX, p. 417, 1912.

The upper horizon from which Nicholson obtained his type-specimen of *M. gregaria* at Kershope Foot forms a compact limestone several inches thick. It is made up of small spheroidal nodules about half an inch in diameter, and occurs a short distance below the Fell Sandstone. It can be traced over the whole of North Cumberland and north-west Northumberland from near Rothbury on the east to the Scottish Border at Kershope Foot, and from the headwaters of the Rede in the north to the Shopford district in the south. This layer must therefore have been originally deposited over an area of at least 1,000 square miles. The horizon of the upper band is almost certainly that of the C zone of the Bristol sequence.[1] It is quite possible, therefore, that it is contemporaneous with the Whitehead Limestone of Mitcheldean. This supposition receives support from two other pieces of evidence. In the beds underlying the *Mitcheldeania gregaria* band in North Cumberland occur calcareous nodules largely made up of tubes of *Serpulæ*—an organism which is completely absent from the Westmorland succession, but which is reported by Professor Sibly from the lower limestone shales containing *Mitcheldeania* in the Forest of Dean district. Again, this upper algal layer in Northumberland and Cumberland is almost immediately overlain by the Fell Sandstone Series, while the Whitehead Limestone at Mitcheldean passes immediately upwards into a sandstone, the Drybrook Sandstone of Professor Sibly, which was originally correlated with the Millstone Grit, but was shown by Dr. Vaughan in 1905 to belong to the Lower Carboniferous Series. It would be interesting if further researches should prove the existence of a former gulf at the end of Tournaisian times, running from the Forest of Dean to the east of North Wales, through North Cumberland to the southern slopes of the Cheviot Isle, with a branch given off eastward into Westmorland.

In any case it is a remarkable fact that we have a great development of algal deposits at this period in Gloucestershire, Westmorland, Lancashire, North Cumberland, and Northumberland.

Ortonella.—This form, as already mentioned, occurs in great abundance in the algal band in the '*Athyris glabristria* zone' of the North-West Province. It is found in spherical nodules up to the size of a small orange. In microscopic sections it resembles *Mitcheldeania* in so far as it consists of a series of tubes growing out radially from a centre. It differs, however, from this genus in many important respects. All the tubes are approximately of the same size, and there is no evidence of alternating coarse and fine tufts arranged concentrically, as in the case of *Mitcheldeania*. Further, the tubes are not undulating as in that genus, and therefore in thin slices lie for a long distance in the plane of the section. They are much more widely spaced and show marked dichotomous branching, the bifurcations making a nearly constant angle of about 40°, and there is a strong tendency for the branching to take place in several tubes at about the same distance from the centre of growth, producing a general concentric effect in the nodule.

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[1] *Geology in the Field*, pt. iv, p. 683, and Q.J.G.S., vol. lxviii, p. 547, 1912.

The diameter of the tubes is decidedly less than those in *Mitcheldeania*, being usually little more than half the size of the larger tubes of *M. gregaria.* The nodules of this genus occur in great profusion, contributing largely to the formation of the shaly dolomite at the base of the '*P. globosus* band' throughout the Shap, Ravenstonedale, and Arnside districts in Westmorland and Lancashire.

In addition to these genera there occur also two other encrusting calcareous growths which require mention. The first of these appears in thin sections in the form of a 'festoon-like' growth, surrounding fragments of Calcareous Algæ, especially *Mitcheldeania* and *Ortonella.* I have met with it abundantly in the 'Algal band' in the north-west of England, but it also occurs not infrequently associated with *Mitcheldeania* in the Whitehead Limestone in the Forest of Dean, while a similar structure occurs associated with *Mitcheldeania gregaria* in North Cumberland.

The other deposit is the form already alluded to under the term *Sphærocodium*, which I have found forming considerable masses of rock in many districts where the Lower Carboniferous beds are exposed, not only in Westmorland and North Cumberland, but also in the Bristol district, the Forest of Dean, and South Wales.

Foreign Carboniferous.

From its general similarity to the British deposits we might expect to find examples of an algal development in some portion of the Belgian Lower Carboniferous succession. As already mentioned, large masses of encrusting calcareous deposits have been described by Gürich[1] from the Visean Limestones of the Namur Basin as *Spongiostroma*, etc., which, though referred by him to the Rhizopoda, may very well be calcareous precipitates deposited by algal influence. Many of these deposits are similar to those mentioned above from British rocks.

No undoubted remains of Calcareous Algæ have, however, yet been recorded from these Belgian rocks. It may be of interest, therefore, to mention the recent discovery by Professor Kaisin, of Louvain, of certain algal remains in the beds overlying the Psammites-de-Condroz at Feluy on the Samme. The form found here resembles *Ortonella* of the Westmorland rocks, but the tubes are much finer, and it may turn out to represent a species of *Mitcheldeania.* During a recent visit to Belgium I had the pleasure of visiting the Comblain-au-Pont Beds, in the Feluy section with Professor Kaisin, and, although these beds have been previously classed as Devonian, I agree with him that they probably belong to the base of the Carboniferous and correspond approximately to K of the Bristol sequence. In the company of Professor Dorlodot and Dr. Salée, I also visited the chief sections of the Visean, and we succeeded in discovering at least three horizons at which nodular concretionary structures, probably referable to algal growths, occurred.

In 1908 Schubert (Jahrb. d. k. k. geol. Reichsanstalt, 1908, Bd. 58, Hft. 2, pp. 347, 382, pl. xvi, figs. 8–12) published descriptions of two new forms of the Siphoneæ—*Mizzia* and *Stolleyella*—from the

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[1] Mém. du Musée Roy. d'Hist. Nat. de Belgique, t. iii, 1906.

Fusulina Limestone of the Velebit district in Dalmatia, while later, in 1912 (Verh. d. k. k. geol. Reichsanstalt, 1912, p. 330), he records further examples of these genera from specimens, collected by Koch, of rocks of the same age in Croatia. The same genera have also been recorded by Karpinsky from the Fusulina Limestone of Japan (Verh. d. Russ.-kais. Min. Gesell. St. Petersb., ser. II, Bd. 46, 1908, p. 257, pl. iii).

Still more recently another form of *Girvanella* has been described by Yabe from the (?) Carboniferous rocks of San-yu-tung and other localities in China under the name of *G. sinensis*.[1]

PERMIAN AND TRIAS.

In Britain I have met with no reference to the presence of Calcareous Algæ in rocks of this period, but quite recently Mr. Cunnington, of H.M. Geological Survey, sent me a few nodules from the base of the Permian near Maxstoke; in thin sections they resemble very closely specimens of *Spongiostroma* from the Carboniferous Limestone described above.

On the Continent masses of limestone, composed almost entirely of remains of *Diplopora* and *Gyroporella*, have long been known from the Muschelkalk and Lower Keuper beds of the Eastern Alps, notably the Mendola Dolomite, the Wetten Limestone of Bavaria, and from similar horizons in Tyrolian Alps. In the Lombard Alps the same facies reappears, and *Diplopora annulata* occurs abundantly in the well-known Esino Limestone above Varenna, while recent work by Cayeux (C. R. Acad. Sci., Paris, tome clvii, p. 272, 1911, and Exploration Arch. de Délos, Paris, vol. iv, pt. i, 1911), Négris (C. R. Acad. Sci., Paris, tome clv, p. 371, 1912), and Renz (Centralb. f. Min., 1911, pp. 255, 289, and ibid., 1912, p. 67; also Jahrb. österr. geol. R. A., lx, pt. iii, p. 451, 1910) on the Triassic rocks of the mainland of Greece and the Cyclades shows the wide distribution of the Algal limestones in the south and south-east of Europe.

In 1891 Rothpletz[2] showed that certain spherical bodies in the Triassic beds of St. Cassian, formerly regarded as oolitic structures, were in reality algal growths, and referred them to a new genus, *Sphærocodium*, on account of their apparent resemblance to the living form *Codium*. He describes them as encrusting organisms forming nodules up to several centimetres in diameter. They contribute substantially to the rocks in which they occur, and are found especially in the Raiblkalk, the Kossenerkalk, and the Plattenkalk.

JURASSIC.

The Mesozoic rocks of Britain contain but few examples of marine algal limestones, and important occurrences are confined to the Jurassic rocks. The forms met with are limited to two genera, *Girvanella* and *Solenopora*.

Tubes of *Girvanella* occur fairly abundantly in the British Oolites, especially in the well-known Leckhampton Pisolites, and Mr. Wethered, who has made a special study of oolitic structures, appears inclined to refer all oolitic structures to organic agency of this nature.

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[1] H. Yabe, Science Reports of the Tâhoku Imp. Univ., ser. II, Geology, vol. i, No. 1, Japan, 1912.

[2] Zeitsch. d. deut. Geol. Ges., vol. xliii, pp. 295–322, pls. xv–xvii, 1891.

The examples of *Solenopora* met with in the Great Oolite[1] and Coral Rag are of special interest. In both cases they attain very much larger dimensions than any species yet discovered in the Palæozoic rocks.

At Chedworth, near Cirencester, I have collected masses of *Solenopora jurassica*, measuring up to a foot across, in which the original pink tint is still so conspicuous on freshly fractured surfaces as to give rise to the local appellation of 'Beetroot Stone', and the colour also reminds one of the red algæ growing in great profusion at the present day in the Gulf of Naples.

It is also recorded from the same horizon by Dr. Brown[2] from near Malton in Yorkshire, and also, on the authority of the late Mr. Fox Strangways, by Rothpletz.[3]

In Yorkshire, however, one form undoubtedly occurs at a higher horizon, namely, in the Coral Rag of the Scarborough district, where it is well known to local collectors. Specimens which I have collected from this horizon at Yedmandale and Seamer also attain a considerable size—up to 3 inches in their longest dimension.

The name *Solenopora jurassica* was given by Nicholson in manuscript to specimens from Chedworth, and was adopted by Dr. Brown in his description of the specimens from both Chedworth and Malton in Nicholson's collection.

Rothpletz points out that specimens examined by him from Yorkshire differ from the genotype in the fact that the cells are typically rounded in cross-section and by the absence of perforations in the cell-walls, and he therefore proposes to separate it as a new genus *Solenoporella*. It seems probable that some confusion has arisen between the specimens to which Nicholson originally gave the name of *S. jurassica* from the Great Oolite of Chedworth and other specimens from Malton from a higher horizon[4]—the Coral Rag. I have collected specimens from both horizons and consider that the Chedworth specimens, to which the name *Solenopora jurassica* was originally given, represent a species of true *Solenopora*, showing closely packed cells with polygonal outline in tangential section; the form from the Coral Rag of Yorkshire, with distinct circular outline to the tubes in tangential section, is specifically, if not generically distinct, and is that described by Rothpletz as *Solenoporella*.

If this view be correct we should continue to speak of the specimens from the Great Oolite at Chedworth as *Solenopora jurassica*, while those from the Coral Rag of Yorkshire must be known as *Solenoporella* sp., Rothpletz.

Foreign Jurassic.

In foreign Jurassic rocks the recorded occurrences of Calcareous Algæ are surprisingly few.

Quite recently, however, Mr. H. Yabe[5] has described a new species of *Solenopora*, under the title *Metasolenopora Rothpletzi*, from the

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[1] Proc. Cot. Nat. Club, vol. x, p. 89, 1890.

[2] GEOL. MAG., Dec. IV, Vol. I, pp. 145 et seqq., 1894.

[3] Kungl. Svenska Vet. Akad. Handl., Bd. xliii, No. 5, 1908.

[4] See Fox Strangways, GEOL. MAG., Dec. IV, Vol. I, p. 236, 1894.

[5] Sci. Rep. Tâhoku Imp. Univ. Japan, 1912.

Torinosu Limestone, Japan. This discovery is of interest, as it carries the known occurrence of *Solenopora* up to the base of the Cretaceous, in which formation *Lithothamnion* appears and thenceforward becomes the chief representative of the rock-building Coralline Algæ.

CRETACEOUS.

We here reach the period when *Lithothamnion* and its allies begin to make their appearance. They have not yet been recognized in British rocks, but are widely distributed in deposits on the Continent. They occur in the Cenomanian of France, in the Sarthe and the Var, but especially in the Danian of Petersburg, near Maestricht.

Other forms which may be mentioned are *Diplopora* and *Triploporella*. The former is met with abundantly in the Lower Schrattenkalk in certain districts, especially Wildkirchli, where it plays a considerable part in the formation of the deposit.[1]

TERTIARY.

In Britain no example of marine Calcareous Algæ have, so far as I am aware, yet been reported, but considerable deposits of freshwater limestone, rich in remains of *Chara*,[2] have for long been known from the Oligocene of the Isle of Wight.

Foreign Tertiary.

On the Continent, however, thick deposits rich in *Lithothamnion* and *Lithophyllum* have been known for many years. Of these I may mention especially the well-known Leithakalk of the Vienna Basin and Moravia. It will be remembered that it was these deposits which formed the subject of Unger's important monograph in 1858.[3]

CONCLUSIONS.

The facts given above regarding the geological distribution and mode of occurrence of these organisms lead us to several interesting conclusions. In the first place there can be no doubt from the examples described above that they play a very striking part as rock-builders at many different horizons in the geological series. At the same time it is evident that not only are certain forms restricted to definite geological periods but also that they had a wide geographical range, and on this account these organisms will often be found valuable as zonal indices either alone or in conjunction with various other organisms. As an example of this wide distribution we may cite *Solenopora compacta*, which flourished so abundantly during Llandeilo–Caradoc times not only in the Baltic area and Scotland but also in England, Wales, and Canada; again, the wonderfully persistent development of the *Rhabdoporella* facies over the whole of the Baltic area at the close of Ordovician times was of so marked a character that even boulders of these rocks scattered over the North German plain can be made use of in tracing the direction of flow of the ice-sheet during Glacial times.

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[1] Arbenz. Vierteljahrsschr. Naturf. Ges. Zurich, vol. liii, pp. 387–92, 1908.

[2] This form, though till lately included among the green algæ, is now usually placed in a distinct group—the Charophyta.

[3] Denksch. k. Akad. Wiss. München, vol. xiv, p. 13, 1858.

To take examples nearer home. The '*Ortonella* Band' found throughout Westmorland and North Lancashire near the summit of the Tournaisian occurs so constantly at the same horizon as to constitute one of the most valuable zonal indices in the succession in the North-West Province, and can not only be used with the greatest confidence for correlating widely separated exposures, but it has also afforded valuable evidence of tectonic disturbances. Other examples are supplied by the '*Girvanella* Nodular Band' at the base of the Upper Dibunophyllum Zone, and the *Mitcheldeania gregaria* beds in the North of England and in the Forest of Dean.

Again, the presence of these organisms at particular horizons furnish us with interesting evidence as to the conditions which obtained during the accumulation of the deposits in which they occur.

At the present day Calcareous Algæ flourish best in clear but shallow water in bays and sheltered lagoons. As a good example we may take the Algal banks in the Bay of Naples, described by Professor Walther,[1] where *Lithothamnion* and *Lithophyllum* flourish to a depth of from 50 to 70 metres. There is seldom any muddy sediment on these banks, though detrital limestone fragments are widely distributed. Another interesting point is the constant association of fossil Calcareous Algæ with oolitic structure and also with dolomite.

Thus oolites occur in connexion with *Solenopora* in the Lower Cambrian of the Antarctic, in the Craighead Limestone at Tramitchell, in the Ordovician rocks of Christiania and the Silurian of Gotland, and in the Lower Carboniferous Limestone of Shap; while in the Jurassic rocks of Gloucestershire and Yorkshire this genus occurs associated with the most typical oolitic development to be met with in the whole geological succession. Though Mr. Wethered has made out a good case for the constant association of *Girvanella* tubes with oolitic grains there are many cases in which this association cannot be traced. M. Cayeux[2] in writing of a mass of *Girvanella* from the ferruginous oolites of the Silurian rocks of La Ferrière-aux-Etangs expresses his opinion that *Girvanella* encrusts the oolite grains but does not form them, and that it is really a perforating alga of a parasitic nature.

The presence of dolomites in connexion with algal growths at different geological horizons appears to show that the beds have accumulated under definite physiographical conditions similar to those which obtain to-day in the neighbourhood of coral reefs. Such lagoon conditions would tend to come into existence during periods of subsidence or elevation, and this is just what we find when we examine the periods at which these reefs are most persistent.

Thus the Girvan Ordovician lagoon-phase occurred during an elevation which culminated with the deposition of the Benan Conglomerate; the Lower Carboniferous 'Algal band' in Westmorland was laid down during the subsidence which followed the Old Red Sandstone continental period, while the Upper *Girvanella* Nodular band occurred

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[1] Zeitsch. deut. Geol. Ges., 1885, p. 229. Abh. Königl. Preuss. Akad. Wiss., 1910.

[2] Comptes Rendus Acad. de Sci. 150, 1910, p. 359.

Formations.	British	Localities.	Australia and Adagascar.	Antarctic.
Newer Tertiary .	—	—	—	—
Miocene . .	—	—	—	—
Oligocene . .	—	—	ithothamnion: North Madagascar.	—
Eocene . . .	—	—	—	—
Cretaceous . .	—	—	—	—
Jurassic . .	—	—	—	—
Purbeck.	—	—	—	—
Coral Rag.	? *Solenoporella* .	Yedmandale, Seamer, Ruston, etc., and Malton.	—	—
Great Oolite.	*Solenopora jurassica*	Chedworth, near Cirencester.	—	—
Trias . . .	—	—	—	—
Permian . .	? *Spongiostroma* .	Maxstoke, near Coventry.	—	—
Carboniferous—Upper & Lower .	—	—	—	—
Base of Upper *Dibunophyllum* zone.	*Girvanella* . .	Coldstream, Penygent, Humphrey Hd., etc. Tortworth, Clifton.	—	—
Athyris glabristria zone.	*Ortonella* . . .	Shap, Orton, Ravenstonedale, Meathop, etc.	—	—
	Solenopora Garwoodi	Shap Abbey, Stone Gill, Meathop, Clifton.	—	—
	Mitcheldeania gregaria, Mitcheldean Whitehead Group	Scottish Border, Cumberland, Northumberland.	—	—
	M. Nicholsoni, Mitcheldean, Lower Limestone Shales	Scottish Border and Cumberland.	—	—
	? *Spongiostroma* .	Widely distributed at several horizons, especially at Orton.	—	—
Devonian . .	? *Girvanella* . .	Hope's Nose Limestone.	—	—
Silurian—Ludlow.		—	*irvanella* ? *Mitcheldeania.*	—
Wenlock.	*Girvanella problematica* (?)	Mayhill, Malvern, etc.	—	—
Ordovician—Upper Caradoc. Ardmillan Series (Whitehouse Group).	*Solenopora lithothamnioides*	Shalloch Mill, Girvan	—	—
Llandeilo-Caradoc (Stinchar and Craighead Limestone).	*Girvanella problematica*	Girvan district.	—	—
	Solenopora compacta, var. *Peachii*, *S. fusiformis*, *S. filiformis*	Girvan district; Hoa Edge, Shropshire; Yat Hill, Radnorshire.	—	—
Cambrian . .	—	—	*irvanella.*	*Solenopora*

when the marine period of the Lower Carboniferous was drawing to a close and a general elevation was taking place. Similar conclusions could be drawn from the Gotlandian and other periods recorded above.

In conclusion I venture to express the hope that however incomplete the account of the succession of forms which I have given may be, it may nevertheless help to stimulate an interest in these rock-building Algæ and encourage geological workers in this country to turn their attention to a hitherto neglected group of forms of great stratigraphical importance.

In the accompanying Table II are set out the more important Algal horizons so far described in the Palæozoic and Mesozoic rocks, together with a few typical occurrences of Tertiary age, but the table makes no claim to be exhaustive, as additional evidence of the importance of these organisms is constantly coming to hand; thus since the publication of the last number of this Magazine I have received from Professor Rothpletz[1] a description of a new form of Spherocodium, *S. zimmermanni*, which he finds playing an important part in the 'so-called conglomerate' in calcareous sandstone near Liebichan Silesia, formerly classed as Culm, but which has recently been shown by Zimmermann to be of Upper Devonian age.

V.—THE SUB-CRAG FLINTS.

By J. REID MOIR, F.G.S.

AT the meeting of the British Association held at Birmingham last September, Professor W. J. Sollas, F.R.S., read a paper in which the Sub-crag flints I have discovered were rejected as not being of human workmanship. Professor Sollas mainly based his arguments upon certain flints found upon the seashore at Selsey Bill, Sussex, many of which have been collected by Mr. E. Heron Allen of that place. In August of this year I paid a visit to Selsey and, owing to the kindness of Mr. Heron Allen, was enabled to carefully examine his collection of flints and the exact places on the shore from which they were derived.

The conclusions I arrived at regarding these specimens and their method of fracture are as follows:—

An examination of the flints in Mr. Heron Allen's collection from the surface of the Eocene clay at Selsey Bill clearly shows that they differ widely both in mineral condition and 'patination', and do not belong to one geological period. When each series is arranged apart the specimens are seen to resemble very closely those found in East Anglia (1) below the Red Crag, (2) in the Middle Glacial Gravel, and (3) in the Chalky Boulder-clay.

The occurrence of flints of these three series at one horizon in the South of England is of some interest and importance, and seems to indicate the breaking up of these deposits and subsequent deposition of their material at the spot where they are now found. The specimens

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[1] "Über *Sphærocodium Zimmermanni* aus dem Oberdevon Schlesiens": Jahrb. d. k. Preuss. Geol. Landesanstalt, 1911, Bd. xxxii, T. ii, Hft. i, p. 112, pls. 4, 5.

FORMATIONS.	BRITISH	LOCALITIES.	BALTIC PROVINCES.	NORTH AMERICA.	MIDDLE EUROPE.	ALPS, ETC.	SOUTH EUROPE.	ASIA.	JAPAN AND PHILIPPINES.	AUSTRALIA AND MADAGASCAR.	ANTARCTIC.
Newer Tertiary	—	—	—	—	—	—	*Lithothamnion*: Girgenti.	—	—	—	—
Miocene	—	—	—	—	—	Leithakalk, with *Lithothamnion*, Vienna Basin and Moravia.	*Lithothamnion*: Alhama, etc., Spain.	*Lithothamnion*: Lake Wan, Armenia.	*Lithothamnion*: Philippines.	—	—
Oligocene	—		—	—	—	*Lithothamnion*: Val Sugana.	—	—	—	*Lithothamnion*: North Madagascar.	—
Eocene	—		—	—	*Lithothamnion*: Ariege. *Dactylopora*: Paris (Calcaire Grossier).	—	—	*Lithothamnion*: Trebizond, etc., Armenia.	—	—	—
Cretaceous	—		—	—	[Danian & Senonian] *Lithothamnion*: Maestricht, Marseilles; Pisolitic Limestone, Paris.	*Diplopora*, *Triploporella*: Schrattenkalk, Wildkirchli.	—	Turonian—*Triploporella*: Lebanon.	—	—	—
Jurassic	—	—	—	—	—	*Diplopora*.	—	—	*Metasolenopora*: Japan (Torinosu Limestone).	—	—
Purbeck. Coral Rag.	? *Solenoporella*	Yedmandale, Seamer, Ruston, etc., and Malton.	—	—	—	—	—	—	—	—	—
Great Oolite.	*Solenopora jurassica*	Chedworth, near Cirencester.	—	—	—	—	—	—	—	—	—
Trias	—	—	—	—	*Diplopora*: Alsace-Lorraine (Muschelkalk).	*Diplopora*, *Gyroporella*, *Sphærocodium*: Tyrol (Wengen St. Cassian, etc.). *Diplopora*, *Gyroporella*, etc.: Lombardy (Esino Limestone). *Gyroporella*: S. Tyrol.	*Diplopora*, *Gyroporella*: Greece, mainland, and Cyclades.	—	—	—	—
Permian	? *Spongiostroma*	Maxstoke, near Coventry.	—	—	—	—	—	—	—	—	—
Carboniferous Upper & Lower	—	—	—	—	—	*Mizzia*, *Stolleyella*: Velebit, Dalmatia, and Croatia.	—	'Calc-Algæ': Lake Urmi, Armenia.	*Mizzia*, *Stolleyella*: Akasaka, Mino, Japan. *Girvanella sinensis*: Carboniferous? Japan.	—	—
Base of Upper *Dibunophyllum* zone.	*Girvanella*	Coldstream, Penygent, Humphrey Hd., etc., Tortworth, Clifton.	—	—	*Spongiostroma*: Visean of Namur.	—	—	—	—	—	—
Athyris glabristria zone.	*Ortonella*	Shap, Orton, Ravenstonedale, Meathop, etc.	—	—	Lowest *Ortonella* or *Mitcheldeania* at Feluy.	—	—	—	—	—	—
	Solenopora Garwoodi	Shap Abbey, Stone Gill,[1] Meathop, Clifton.	—	—	—	—	—	—	—	—	—
	Mitcheldeania gregaria, Mitcheldean Whitehead Group	Scottish Border, Cumberland, Northumberland.	—	—	—	—	—	—	—	—	—
	M. Nicholsoni, Mitcheldean, Lower Limestone Shales	Scottish Border and Cumberland.	—	—	—	—	—	—	—	—	—
	? *Spongiostroma*	Widely distributed at several horizons especially at Orton.	—	—	—	—	—	—	—	—	—
Devonian	? *Girvanella*	Hope's Nose Limestone.	—	—	U. Devonian, Silesia: *Sphærocodium Zimmermanni*.	*Sycidium*? Eifel.	—	—	—	—	—
Silurian Ludlow.	—	—	*Spongiostroma*, *Sphærocodium gotlandicum*, *Solenopora gotlandica*: Gotland.	—	—	—	—	—	—	*Girvanella* ? *Mitcheldeania*.	—
Wenlock.	*Girvanella problematica* (?)	May Hill, Malvern, etc.	—	—	—	—	—	—	—	—	—
Ordovician Upper Caradoc Ardmillan Series (Whitehouse Group)	*Solenopora lithothamnioides*	Shalloch Mill, Girvan.	*Rhabdoporella*, *Vermiporella*, *Apidium*, etc.: Bergen, Christiania, South Sweden, Esthonia. *Solenopora compacta*: Christiania, Esthonia.	*Solenopora compacta*: Trenton Limestone, Black River Limestone.	—	—	—	—	—	—	—
Llandeilo Caradoc (Stinchar and Craighead Limestones)	*Girvanella problematica* *Solenopora compacta*, var. *Peachii*, *S.* [illegible], *S.* [illegible]	Girvan district. Girvan district, Hoar Edge, Shropshire: Yat Hill, Radnorshire.	—	*Girvanella* (*Strephochetus*): Chazy Limestone.	—	—	—	—	—	—	—
Cambrian	—	—	—	—	—	—	*Girvanella* (*Siphonema*): Sardinia.	*Girvanella*: Man-t'o Series, China	—	*Girvanella*.	*Solenopora* (Beardmore Glacier).